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Evaluation of Soil and Buried Transuranic Waste Retrieval Technologies for Operable Unit 7-13/14

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December 2002

Idaho National Engineering and Environmental Laboratory
Bechtel BWXT Idaho, LLC

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ABSTRACT

The U.S. Department of Energy, to satisfy the requirements of the Federal Facilities Agreement and Consent Order with the State of Idaho and the U.S. Environmental Protection Agency, is conducting the Waste Area Group (WAG) 7 Operable Unit 13/14 Comprehensive Remedial Investigation/ Feasibility Study at the Idaho National Engineering and Environmental Laboratory. The Comprehensive Environmental Response, Compensation, and Liability Act governs these activities, which involve assessments of contaminants of concern, risk factors, and potential technologies for remediating the site.

This report describes the technologies for retrieving soil and buried transuranic waste at the Subsurface Disposal Area within WAG 7 at the Idaho National Engineering and Environmental Laboratory and presents specific technologies that can be used in this process. The technologies are evaluated for their applicability to the SDA. In addition, effectiveness, implementability, and cost are discussed.

In the attached appendix, several case studies are presented. These case studies were selected for evaluation on the basis of their similarities to conditions or issues presented by the SDA.

The document presents currently available technology performance information and serves as a subtier reference document in the pending WAG 7 Feasibility Study.

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ACRONYMS

AEC	Atomic Energy Commission
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	U.S. Department of Energy
HEPA	high efficiency particulate air
INEEL	Idaho National Engineering and Environmental Laboratory
LDR	land disposal restriction
NRTS	National Reactor Testing Station
RAO	remedial action objective
RFP	Rocky Flats Plant
RI/FS	Remedial Investigation/Feasibility Study
SDA	Subsurface Disposal Area
TRU	transuranic
UXO	unexploded ordnance
VOC	volatile organic compound
WAG	waste area group

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1. INTRODUCTION

The Subsurface Disposal Area (SDA) in Waste Area Group (WAG) 7 at the Idaho National Engineering and Environmental Laboratory (INEEL) has accepted radioactive mixed waste since 1952. SDA pits, trenches, and soil vaults were filled with drums, boxes, cartons, trash, tanks, and other miscellaneous debris that contain transuranic (TRU), low-level radioactive, irradiated fuel materials, and mixed wastes. When full, a disposal unit was covered with several feet of clean soil.

Since December 1991, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Remedial Investigation/Feasibility Study (RI/FS) process has been ongoing at WAG 7 to address the wastes buried at the SDA. With that process currently moving into the feasibility study phase, evaluations of retrieval options for the soil and buried waste at the SDA are needed for the feasibility study to progress. This report has been prepared to research and explore retrieval alternatives of the TRU waste in the SDA, with the goals of:

1. Describing the buried waste at the SDA
2. Identifying technologies that may be used to retrieve soil and buried TRU waste
3. Identifying retrieval technologies at other sites that may apply to the SDA
4. Identifying issues for the effectiveness and implementability of retrieval actions at the SDA.

1.1 Description of Buried Wastes

The following information describes the disposal practices at the SDA. The interval definitions described below are based on descriptions of disposal practices and waste received during the period. The information was derived from the WAG 7 *Preliminary Evaluation of Remedial Alternatives* report (INEEL 2002).

1.1.1 Disposals from 1952 to 1959

The original National Reactor Testing Station (NRTS) Burial Ground, now known as the SDA, was established for disposal of solid waste in 1952. The facility was managed and operated by the U.S. Atomic Energy Commission (AEC) Site Survey Branch. Trenches 1 through 10, excavated between 1952 and 1957, average 1.8 m (6 ft) wide, 900 ft (274.3 m) long, and 13 ft (3.7 m) deep. In 1957, Pit 1 was excavated to dispose of large bulky items. The facility was expanded in 1958 to its current size.

Disposal practices at the SDA classified waste as either routine or nonroutine. Routine solid waste, defined as waste with exposure rates within daily occupational limits, was packaged in cardboard boxes and typically consisted of paper, laboratory glassware, filters, metal pipe fittings, and other items contaminated by mixed fission products. The boxes were taped shut and collected in dumpsters that eventually were emptied into the trenches in the burial ground. Nonroutine waste, defined as waste that could exceed personnel exposure limits, was placed either in wooden boxes or in garbage cans. Special transport containers and vehicles hauled the waste to the disposal site. Before 1957, the radiation level was not limited for any disposal and items registering up to 12,000 R/hr were buried. Both routine and nonroutine waste was covered with soil; nonroutine waste was covered immediately, but routine waste boxes could be left exposed until the end of an operating week.

From 1954 to 1957, the SDA also accepted waste shipments for permanent disposal from the Rocky Flats Plant (RFP) under the authorization of the AEC. The RFP TRU waste, packaged in drums or wooden crates, was stacked horizontally in pits and trenches along with INEEL generated low-level mixed fission product waste.

1.1.2 Disposals from 1960 to 1963

From 1960, the SDA accepted approved shipments from off-Site generators, in addition to the RFP and INEEL waste for disposal. From 1960 to 1963 when the Interim Burial Ground Program was active, Trenches 16 through 25 and Pits 2 through 5 were open for waste disposal. The trenches received some mixture of stacked or dumped RFP TRU waste, INEEL waste, and off-Site waste. Beginning in November 1963 and continuing until 1969, drums from the RFP were dumped into pits rather than stacked to reduce labor costs and personnel exposures.

1.1.3 Disposals from 1964 to 1969

By the mid-1960s, concern about the environmental impacts of waste disposal significantly influenced waste management practices. Modifications to procedures for permanent interment included increasing the minimum trench depth from 0.9 to 1.5 m (3 to 5 ft), lining the bottoms of the trenches with at least 0.6 m (2 ft) of soil underburden, compacting the waste by dropping a heavy steel plate on the waste dumped in trenches, and increasing the cover over each disposal area from a minimum soil cover of 0.6 to 0.9 m (2 to 3 ft). These modifications were implemented between 1964 and 1970. In addition, TRU disposal was discontinued in 1969. Instead of burying TRU waste, the containers were retrievably stored by stacking them aboveground.

To facilitate the evaluation of retrieval technologies, generic cross-sections of the waste types buried in the pits, trenches, soil vault rows, Acid Pit, and Pad A are presented in Figure 1. Figures 2 and 3 show the practices during the 1960s of wastes being placed in the trenches and pits.

1.2 Retrieval Action General Considerations

As a remedial action, retrieving low-level radioactive and hazardous soil and buried waste from a site offers a number of benefits. For some sites, retrieval may be the only technology available that can achieve the goals established for remediation. Removing the waste from a site allows treatment to reduce the toxicity and mobility of many chemicals and reduce the volume of waste. Once removed, the material can be repackaged into safe, approved containers and managed in accordance with regulatory requirements. Consequently, retrieval at best removes the residual risk from the site (when the material can be disposed off-Site or treated to destroy or stabilize hazardous constituents) and at least reduces the magnitude of risk by implementing engineered controls. Typically, after retrieval is complete, the site can be backfilled with clean soil and returned to use by human and ecological users.

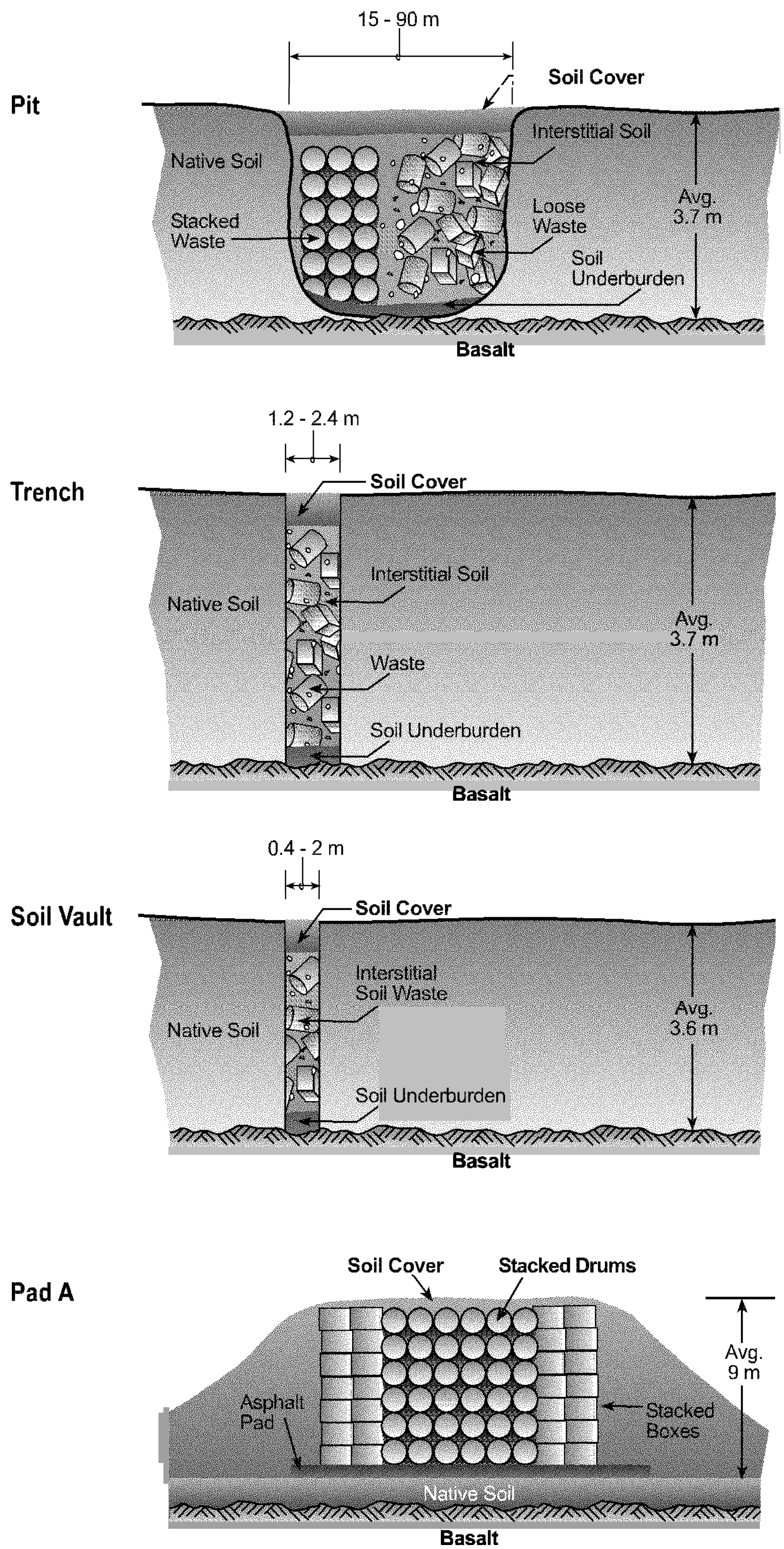

Figure 1. Generic cross section of waste sites.

Figure 2. Trench disposal practices.

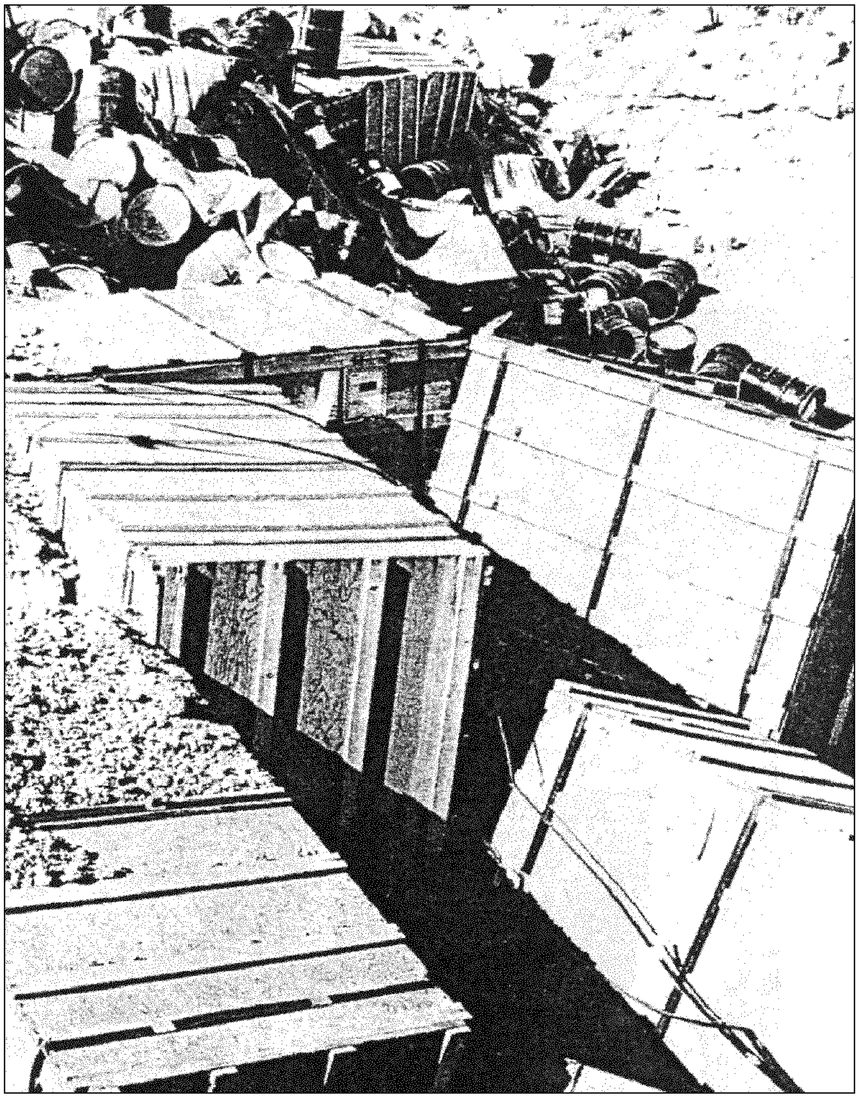

Figure 3. Pit disposal practices at Pit 10.

The design and construction of a retrieval system would be multifaceted and would have to account for the numerous controls required to mitigate the threat of exposure and release. Several systems designed for highly contaminated environments have been demonstrated and are available. Methods of contamination control include Moducon structures, strippable coatings, aerosol fogs, and ventilation systems. Technologies that may be applied to the excavation procedures include pressurized air cabins, shielded equipment, and remotely operated vehicles. Though individual technologies designed for highly contaminated areas are available, the design and construction of the system would have to be comprehensive and may require small retrieval tests before full-scale operations.

For large-scale excavations in radioactive environments, the process of retrieving the wastes will be affected and slowed by specific safety requirements. In the case of TRU wastes in particular, the multiple controls required to protect workers and treatments to dispose of the material can significantly slow progress. A typical process flow diagram for retrieval of TRU waste in the SDA, presented in

Figure 4, shows the numerous activities required during retrieval actions. Many of these activities take time to accomplish, and preparing an excavated item for disposal can take days to months. For the duration of the retrieval activities, the risk of exposure and contamination spread must be mitigated and controlled.

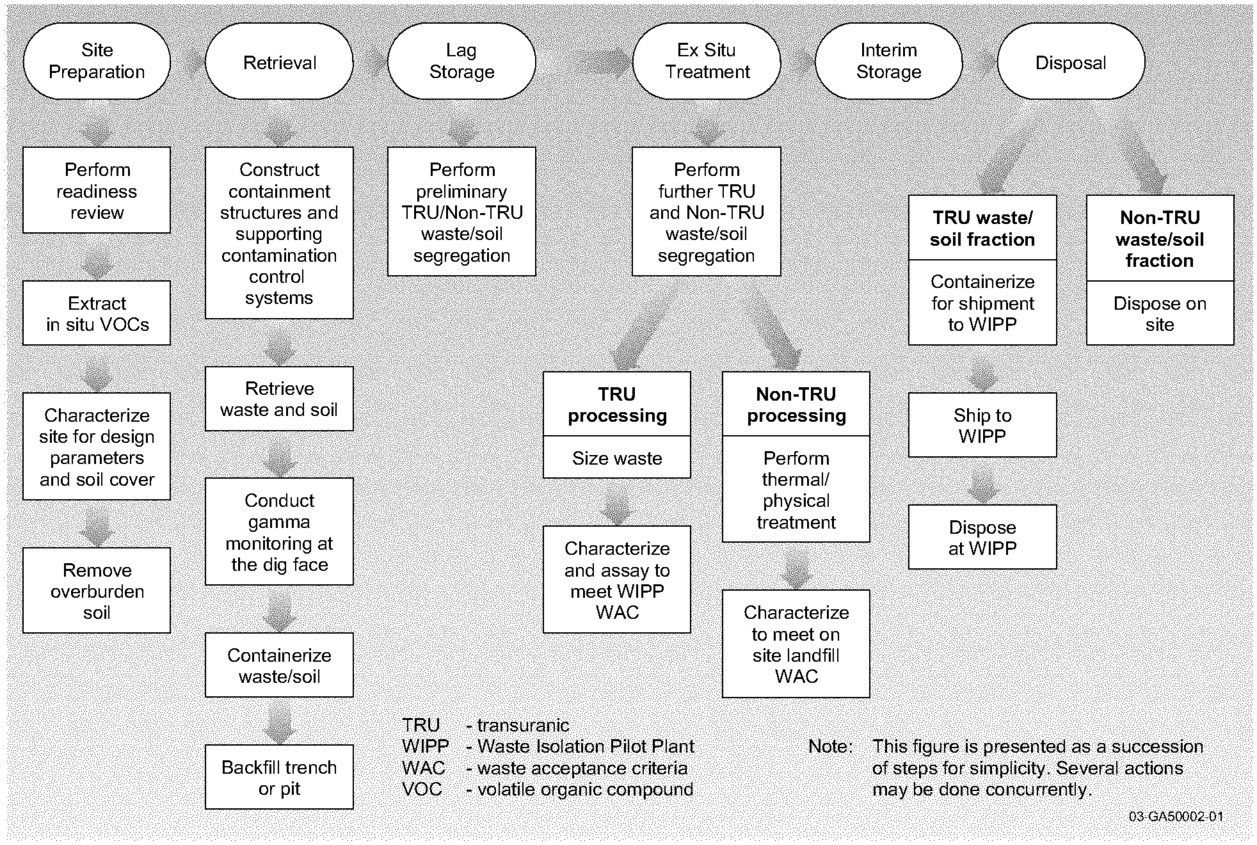

Figure 4. Waste retrieval, treatment, and disposal process flow diagram.

Both TRU and non-TRU waste could be generated from a retrieval action at the SDA. TRU material would be shipped off-Site and consideration should be given to the amount of characterization required to meet applicable Waste Acceptance Criteria (WAC), the number of shipments on the highways or railroads, and the capacity of the disposal site. Transporting the waste to a disposal facility increases the potential for human exposure and spread of contamination, though this risk can be managed. In the case of large-scale excavations involving TRU waste, the cost to characterize, package, and transport all retrieved waste for off-Site disposal may be significant. To reduce costs, on-Site treatment and disposal of non-TRU waste in a specially constructed engineered facility is anticipated.

2. TECHNOLOGY DESCRIPTION

A number of technologies can be used to retrieve soil and buried waste, including conventional heavy excavation equipment, hermetically sealed manually operated heavy excavation equipment (e.g., with a sealed and pressurized cabin with either supplied or filtered air), and remote-operated equipment and controls. Standard heavy construction equipment comprises most of the equipment used for excavation of soil and buried waste. This equipment has been proven at hazardous and radioactive wastes sites across the nation. Therefore, this report focuses on excavation equipment and remote technologies that may be required for waste retrieval actions at the SDA.

The radioactive and chemical materials present in the SDA pose a significant potential for airborne release and exposure to remediation workers Additionally, past retrieval efforts indicate these materials are difficult to control during retrieval actions. Of primary concern is the retrieval of TRU, reactive, and hazardous waste.

Table 1 describes some conventional heavy excavation equipment and remote technologies and their potential applicability to the SDA. This list is not meant to be all-inclusive and other equipment may be available. More detailed descriptions of the technologies in Table 1 can be found in *Survey of Materials-Handling Technologies Used at Hazardous Waste Sites* (EPA 1991), *Hot Spot Removal System, System Description* (INEEL 1997), and *Technical Alternatives Baseline Report* (BHI 2000).

Table 1. Description of waste retrieval equipment.

Technology	Description	Applicability to SDA
Standard Construction Equipment		
Backhoe	Crawler-mounted or tire-mounted subsurface excavators capable of digging small areas, with a typical bucket size of 1.5 m^3 (2 yd^3). Auxiliary equipment can include a clamshell bucket, drum grapplers, dippers, loader buckets, and hammers.	Useful for trench digging and area excavation up to 13.7 m (45 ft) depth; linear reach less than 30.5 m (100 ft).
Front-End Loader	Crawler-mounted or tire-mounted excavators capable of digging, lifting, dumping, and hauling materials. Bucket size is up to 15 m^3 (20 yd^3).	Applicable for excavating large areas with short travel distance requirements (less than 91 m (300 ft).
Bulldozers	Crawler-mounted tractor with a blade and bucket for surface work.	Applicable for removing surface layers, clearing surface debris, and general earth moving. Not useful for buried waste retrieval.
Trencher	Wheeled excavator capable of excavating and grading. Commonly referred to as a ditch witch; can be accessorized with a backhoe, backfill blade, auger, and remote handling devices.	Applicable for small-scale digging.
Vacuum/Soft Trencher	Vacuum removal of soil without disturbing large debris. Can use jetted air to loosen soil before vacuum removal.	May be used to remove loose soil at the digface. Not effective in retrieving buried waste.

Table 1. (continued).

Technology	Description	Applicability to SDA
Soil Skimmer	Removal of thin layers of soil in a controlled manner.	Applicable for removing thin layers. Not effective in retrieving buried waste.
Skid-Steer Loader	Excavator similar to a front-end loader, but usually smaller in size. Commonly referred to as a Bobcat.	Applicable for small-scale excavation, drum loading and transport, material handling, and site preparation. Not useful for buried waste retrieval.
Remote Excavators		
Brokk	Remote-controlled excavator with telescoping arm capable of full articulation. Available with several different end-effectors that could be used for hammering, cutting, and scooping wastes. The largest Brokk can reach approximately 4 m (13 ft) below ground surface (bgs).	Applicable for soil and buried waste at the SDA. Demonstrated and used at Hanford for remote retrieval of high-dose debris from the F Reactor fuel storage bin and at INEEL for demolition projects.
Kiebler Thompson	Remote-controlled excavator with telescopic boom capable of moving in three dimensions. Available with several end-effectors. The largest Keibler Thompson machine can reach approximately 5 m (16 ft) bgs.	Applicable for soil and buried waste at the SDA; similar to the Brokk.
Remote-Operated Excavator	Excavator mounted on a wheeled undercarriage that was developed to retrieve unexploded ordnance. A television provides images for remote excavation. The only such excavator is currently used at an Air Force base.	Though this excavator may not be available for use at the SDA, the concept and design may be applied.
T-Rex (front shovel excavator that would require modification for use)	A tele-operated, heavy-lift, long-reach excavator designed to retrieve boxes, drums, and containers with a front shovel excavator. Controls can be operated up to 381 m (1,250 ft) from the excavator.	Applicable to SDA buried waste that can be removed by front shovel excavators. Modifications would be necessary for backhoe end-effector operation. Developed at INEEL.
Front-End Loader (with a 2.75 yd^3 bucket)	Remote control developed for use on a front-end loader. Provides 3-dimensional color video/audio feedback that can be controlled from 457 m (1,500 ft) away. System could be modified for use on excavators.	Applicable to front-end load operations. May be modified for backhoe excavators, though this adaptation has not yet been developed.
Teleoperated Excavator (using T-Rex Remote Control Kit)	Remote-controlled excavator (bucket and thumb) adapted for hazardous environments such as unexploded ordnance (UXO) using sensors, controllers, and hydraulic components.	Applicable to the SDA buried waste; can be used to dig, trench, and cut.
Automated Ordnance Excavator	Remote-controlled excavator with extended reach capability, developed for UXO removal. Can grasp objects such as drums and boxes.	Applicable for soil and buried waste at the SDA.
Small Emplacement Excavator	Military tractor with front-end loader and backhoe remote operation for retrieving buried waste and soil. System can be controlled from 0.8 Km (0.5 mile) away.	Applicable for soil and buried waste at the SDA.

Table 1. (continued).

Technology	Description	Applicability to SDA
Remote Excavator, Hitachi Excavator, Innovative End-Effector (IEE), and Self-Guided Transport Vehicle	Standard excavator with end-effectors (such as buckets, rippers, and breakers) used for buried waste retrieval. System can be controlled inside cab, via a remote tether or from 762 m (2,500 ft) away.	Applicable for soil and buried waste at the SDA. Demonstrated at INEEL.
Modified Bobcat	Remote-controlled skid steer loader with a Bobcat vehicle base with barrel grapple, sweeper, and bucket attachments. Modified for hazardous environments, remote kit for other excavators.	Small excavator capable of retrieving soil and buried waste at the SDA. Control system can be applied to larger excavation equipment.
Standard Construction Equipment With Modifications		
Sealed and Pressurized Cabin, with Filtered Air Intakes and Extracts	Standard construction equipment with modifications made to the cabins. The sealed and pressurized cabin utilizes filtered air (through high-efficiency particulate air [HEPA] filtration).	Applicable for soil and buried waste at the SDA, especially in the TRU environments where worker protection from the source material is necessary.
Sealed and Pressurized Cabin, with Supplied Air	Standard construction equipment with modifications made to the cabins. The sealed and pressurized cabin utilizes supplied air.	Applicable for soil and buried waste at the SDA, especially in the TRU environments where worker protection from the source material is necessary.
Remote Controllers		
Remote Control Kit for Gantry Crane or Excavator	Remote control technology that can operate any track-size mounted excavator or gantry crane at a distance of 1.6 Km (1 mile) away.	Applicability is related to excavation equipment selected for retrieval.
Compact Remote Operator Console	Fully functional control system that can operate remote equipment. Adaptable to a variety of robotic and remote systems.	Applicability is related to excavation equipment selected for retrieval. Has been deployed at INEEL.
Coordinated Motion Control	Control system for hydraulic equipment such as excavators and backhoes.	Applicability is related to excavation equipment selected for retrieval.
Remote Kit for Excavators (developed and implemented on dozer)	Remote control technology that was developed to control the end-effectors and driving functions of a dozer. Not field tested.	May be applicable to excavation equipment, but is not proven.
Remote Cranes		
Cooperative Telerobotics Retrieval System	System consists of an 24.4 m (80-ft)-wide girder, two trolley assemblies with vertically telescoping masts, two manipulators, trolley, and a 5-ton hoist that operates remotely.	Unit is at the INEEL.
RoboCrane	Cable-driven platform for a parallel link manipulator. Provides load control via teleoperative, graphic off-line programming, and hybrid control modes.	In advanced development stage.
Swing Free Technology for Controlling Cranes	Operation of a gantry crane without large swinging motions.	Proven on a 30-ton crane. Unknown adaptability on other crane sizes.

Table 1. (continued).

Technology	Description	Applicability to SDA
Remote End-Effectors		
Safe Excavation	High-pressure probe dislodges compacted soil, other hardened materials using an air-jet/vacuum end-effector system. Vacuums up soil.	Usable system to break up and remove soil.
2-Armed, Tethered Hydraulically Powered Interstitial Conveyance System	Crane-deployed with two excavators and vacuums designed for low-level radiation fields. Maximum pickup load of 317 Kg (700 lb).	Used in conjunction with a gantry crane for selective retrieval.
Tentacle, Highly Manipulative	Teleoperated manipulator and bellows actuator.	Used with a crane and manipulator. Limited load capabilities (less than 1814 Kg (4,000 lb).
Hydraulic Impact End-Effector	Water cannon for tank applications attached to a robotic manipulator arm and used to break up monolithic hard cake forming around risers in tanks.	Used for tanks; resulting mud/sludge is not separable. More design work is needed.
Schilling Tital II	Manipulators deployed by crane for selective retrieval. Basic components include hydraulic system, positioning system, electronics module, and mechanical interface.	Must be deployed from a crane. Manipulators used for retrieval of barrels from soil.
Mineclaw	Manipulator with strong electromagnet to pick up barrels. Custom grapple with a several hundred pound payload and an electromagnet to retrieve metals.	Must be deployed from a crane. Used for barrel retrieval. Not usable on soil; not able to lift 1814 Kg 4,000-lb load.
Confined Sluicing End-Effector	Water-jet designed for waste tank cleanout. Uses high-pressure water-jets to cut material into small pieces and evacuates with a vacuum jet pump. Captures slurry water.	Water-jet would create additional waste. Other units capable of removing soil without additional waste.
Soil Skimmer	Skimmer removes soil overburden in 3-, 4-, and 6-in. increments. Adjustable depth controls the depth of cut without disturbing soil underneath.	Used for removal of overburden. Can be used with other excavators.
IEE	Consisting of three assemblies—a thumb, an attachable/detachable integrated transfer module, and a shovel assembly—capable of soil retrieval and dust-free waste dumping.	Viable method of retrieval for the soil. Use of soil stabilizers would control dust upon dumping.
Couplers, Quick-Change	Available in manual and hydraulic versions. Used on a variety of buckets, rakes, clamps, rippers, and other end-effectors.	May require the use of sizing equipment and end-effectors. Allows for remote changeouts.
Vacuum Systems	Nuclear-grade vacuum systems for contamination control and retrieval of soil with HEPA filtration and critically safe waste-containers.	Usable to extract dust/debris, but not for large areas.

HEPA= high-efficiency particulate air
IEE= Innovative End-Effector
INEEL=Idaho National Engineering and Environmental Laboratory
SDA=Subsurface Disposal Area
TRU=transuranic

2.1 Selection of Retrieval Technologies

The selection of retrieval technology will depend on the remediation requirements established at the site. Each piece of equipment has unique characteristics that make one more desirable than another for certain applications. Table 2 lists the general issues and related factors to be considered in the selection of technologies for the SDA.

Table 2. Factors in the selection of retrieval technologies.

Issue	Factors
Site Specific	Debris characteristics (debris type—metals, plastic, construction, boxes, drums, tanks, pipes, etc.; size—length, width, etc.)
	Waste characteristics (solid, liquid, sludge, chemicals, and associated hazards)
	Weight bearing capacity of the waste
	Extent and rate of waste decomposition
	Density of the waste site
	Extent of excavation (area and depth)
Equipment Specific	Purpose of equipment
	Weight of equipment
	Transportation requirements
	Available attachments, end-effectors
	Ability to inspect, maintain, service equipment
	Availability of equipment (lease, purchase, or design-construct)
	Production rate requirements
	Cost
Specific to the Determination of Selecting Remote Technology	Exposure potential to equipment operators and site workers
	Potential for explosion
	Potential for criticality
	Potential for fire
	Potential for spread of contamination
	Unknown conditions

The use of conventional construction equipment has proven reliable in the past during the retrieval of radioactive materials. However, the type of equipment selected must correspond to the needs of the project. The Equipment Selection Cold Test, a technology development project funded by the U.S. Department of Energy (DOE) and coordinated by the Buried Waste Integrated Demonstration Project, illustrates the process used to select conventional types of equipment. This study focused on the performance of field tests to determine the effectiveness of employing conventional construction equipment to retrieve buried TRU wastes (Valentich 1993). The test evaluated six pieces of equipment to select the most applicable technology for buried waste retrieval and consisted of a 841 m^3 (1,100 yd^3) cold (nonhazardous and nonradioactive) test pit constructed at the Caterpillar, Inc. Edwards Training Center near Peoria, Illinois. The pit was filled with containers packed with simulated waste (e.g., metals, plastics, wood, concrete, and sludge) and large objects such as truck beds, tanks, vaults, pipes, and beams like those disposed at the SDA. A series of commercially available excavators and loaders outfitted with different end-effectors were used to retrieve the simulated buried waste. Table 3 summarizes key goals and findings of the test.

Table 3. Objectives and conclusions of the 1993 equipment selection cold test.

Objective	Conclusion
Evaluate the effectiveness of the full-scale equipment and end-effectors chosen for retrieving buried waste forms typical of buried TRU wastes at the INEEL and other DOE sites.	Full-scale equipment is effective in retrieving buried wastes in forms that are typical at INEEL.
Retrieve an average of 61 m^3 (80 yd^3) per day of simulated buried waste.	The average production rate was nearly 306 m^3 (400 yd^3) per day, but if the equipment was remotized, retrieval rates could be reduced by 50% (153 m^3 or 200 yd^3 per day). Remotization was not field-tested.
Minimize the spread of dust during excavation.	Dust generation was minimal since the soils were fairly moist. Using the thumb end-effector to control/grip material would also help to minimize dust generation.
Determine whether removal of buried waste from belowgrade or abovegrade is more productive.	Both positions were equally productive, but operators preferred the belowgrade position because of enhanced visibility, less risk of digface collapse, and increased safety and feasibility when large objects were removed.
Determine volume rate of retrieval for different waste orientations.	Rates of retrieval were presented in the report.
Determine the correct suite of end-effectors to retrieve buried waste.	The Balderson thumb end-effector on the 325L excavator was preferred over other end-effectors.
Determine how well the technology lends itself to remotization.	Technology to remotize the 325L excavator is currently available.
Produce a rough order-of-magnitude cost to remotize equipment.	The 325L excavator could be remotized in 1993 for a cost of $1,000,000.
Determine whether the use of a closed-circuit television could enhance and improve operator views in the work area.	Information gathered during the test could be used to develop this technology.

Overall, this test proved that buried waste could be retrieved using conventional equipment and end-effectors, and also indicated that such equipment could be remotized. Further tests using personnel-operated equipment were not conducted, and focus was later put on developing remote control technologies.

3. SUBSURFACE DISPOSAL AREA RETRIEVAL EVALUATION

Many sites have used remote excavators and end-effectors when explosion hazards exist or when the condition of the buried waste containers or sources is unknown. Other sites have modified standard equipment so a person in a sealed environment can operate the equipment. Of the retrieval case studies available, 13 demonstrations, studies, and applications performed at different facilities were selected for evaluation based on their similarities to conditions or issues presented by the SDA. These include:

- The Los Alamos Area P Material Disposal Area Retrieval: An activity conducted for a site at the Los Alamos National Laboratory that used remote equipment to retrieve various types of waste, including high explosives-contaminated equipment and materials, uranium, metals, volatile organic compounds (VOCs), and semivolatile organic compounds.

- The Sandia Landfill: A retrieval action at the Sandia National Laboratory for radioactive and weapons-generated waste materials conducted remotely with a combination of conventional and remote equipment.

- Rocky Flats Trench 1: A retrieval activity at the RFP for soils, drums, and debris contaminated with uranium and uranium products performed with conventional equipment.

- Hanford 618-4: Partial remedial activity for a single pit at Hanford, with uranium from unknown origin identified as the primary contaminant.

- Fernald Waste Pits: A retrieval action at the former uranium-processing facility for low-level radioactive waste containing uranium, thorium, and other contaminants.

- The INEEL Solid Radioactive Waste Retrieval Test: A test performed, in part, to determine the techniques required and costs incurred to retrieve contaminated waste containers.

- The INEEL Initial Drum Removal: A demonstration of retrieval, repackaging, and interim storage placement methods for pits containing radioactive waste in stacked drums.

- The INEEL Early Waste Retrieval: A project implemented to retrieve the oldest buried waste at the SDA, with all retrieval operations conducted from an operating area confinement structure.

- INEEL Full-Scale Design to Retrieve Waste at the SDA (Early OU 7-10 Staged Interim Action Project Design): In the late 1980s a group of EG&G and DOE-ID personnel prepared a design for retrieval of Pit 9 (Schofield 2002). After approximately 2 to 3 years, funding was withdrawn. The project was in the preliminary design phase at the time the project ended.

- The INEEL OU 7-10 Staged Interim Action Project Design: A three-stage remediation plan designed to retrieve a small volume of waste (stage II requires retrieval of 200 yd^3 of buried waste and Stage III requires the retrieval of an entire pit) from a TRU and hazardous waste environment.

- Maralinga Rehabilitation Project: This project was implemented from 1996 to 2000 to remediate soils contaminated with plutonium, americium, uranium, beryllium, and other radioactive materials. Remediation activities primarily consisted of removing contaminated topsoil and burying it at depth on-Site. Cabin and engine compartment modifications (sealed and pressurized, with filtered air) to all the soil removal and monitoring equipment were made.

- Calvert City Project: A project that involved soil and sludge remediation of pits containing vinyl chloride. Because of the hazardous characteristics of vinyl chloride, the excavation equipment (large trackhoes) were modified to provide better protection to the operators. This modification included sealing and pressurizing the cabins and supplying them with air from tanks attached to the equipment.

- Weldon Spring Quarry: A retrieval of bulk waste, including radioactive contaminants remaining from the operation of the former uranium materials plant.

Descriptions of these case studies can be found in Appendix A, which also includes a summary table of technologies used in each of the case studies. The information provided by these case studies reflects a limited experience with excavating buried TRU waste, yet indicates that progress is being made in technology application.

3.1 Effectiveness

Retrieving soil and buried waste at the SDA would be effective in achieving remedial action objectives (RAO) and providing for the long-term protection of human health and the environment. However, implementation of the retrieval action itself has the potential to significantly impact human health and the environment. For this remedial action to be effective, several technologies and controls will need to be implemented. Based on a review of demonstrated retrieval actions (summarized in Appendix A), many of the retrieval technologies that will be needed are available. Before some of these technologies can be evaluated for effectiveness in excavation of SDA waste, field tests, mock tests, and/or a small retrieval test may be required before full-scale retrieval is undertaken. Careful consideration should be given to the protection of workers, the public, and the environment because of the potentially significant impacts on human health and the environment. As described in Section 1.2, waste retrieval could pose a risk from inhalation of radioactive and hazardous substances. Controls will be required to prevent inhalation of wastes and radiation exposure to personnel.

Most of the required equipment or technologies to perform a retrieval action have been proven in highly contaminated environments. For example, remote excavators have been proven successful in waste retrieval simulations and have been used at DOE facilities for decontamination and decommissioning . In addition, shielded excavators also have been successfully used at Hanford, and hermetically sealed vehicles have been used at Maralinga. Risks to the maintenance personnel who regularly enter the contaminated work area to work on the retrieval equipment (Sykes 2001) must be controlled. Technologies and designs are available that allow retrieval equipment to be driven into a maintenance area, which could provide a more protected environment. Entrance into the contaminated work area for the retrieval equipment should be limited to nonroutine activities to control this risk. Hermetically sealed retrieval equipment has been proven reliable in highly contaminated environments and, when compared to remote equipment, they are generally less expensive, have fewer maintenance issues, dig more precisely, and can be operated faster (Sykes 2001). In some instances within the SDA, shielding would be required on the equipment, such as Lexan windows with protective film layers, to protect the worker from beta and low energy gamma radiation being emitted from the source. Filtered or supplied air can also be added to the equipment to protect the operator. This has been proven at many sites, including Maralinga and Calvert City. These types of systems may be needed to achieve a production rate that meets the RAOs. Several factors that decrease the production rate of retrieval equipment include the following (Sykes 2001):

1. Remote technologies
2. One piece of equipment to dig, size, and sort
3. Unexpected conditions.

Several factors that increase the production rate of the retrieval equipment are (Sykes 2001):

1. Larger bucket sizes
2. End-effectors readily available for changing operations
3. More than one retrieval operation in progress
4. Second piece of equipment for sizing and sorting.

To meet the RAOs, several types of equipment may be used at the digface, such as an excavator to dig the waste, a sizer/sorter/cutter, and a front-end loader to scrape soil and move material. The amount of segregation and sizing performed at the digface should be weighed against the need to minimize material handling, thereby controlling contamination spread and protecting the worker. Large-sized objects, such as tanks, trucks, and casks, can be sized using large size cutters or plasma arc. If this type of action is not desirable at the excavation, these objects can be moved to the side, worked around, or stabilized, or contamination can be fixated until the object can be handled.

3.2 Implementability

Retrieval technologies are readily implementable at the SDA—they are available, reliable, and proven in hazardous environments. Effort would be required to obtain agreement among necessary parties to retrieve, treat, transport, and dispose of the waste because an administrative process has not yet been established. However, public records show agency and stakeholder preference for retrieval of the SDA waste. Presently, it is not known if there will be adequate capacity at an off-Site facility to dispose of the TRU waste generated in a retrieval action. This would be better defined when waste streams from a retrieval action are determined, technologies are further developed, and treatment performance is known. A retrieval action may need to include provisions for long-term on-Site storage until treatments are developed to handle the material to meet WAC or until a disposal facility is available to accept the waste.

In all likelihood, the equipment required for a retrieval action would have to be modified for this project, given the nature of the waste and site conditions. Examples of the necessary equipment include remote or hermetically sealed devices, containment structures, ventilation systems, contamination control devices, treatment units, and packaging facilities. Examples of modifications to retrieval equipment include adding HEPA filtration to an engine for contamination control or supplied air to the cab of the equipment for personnel protection. Training the workers would be required to implement this alternative; however, it is expected that the equipment and training would be readily available.

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